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Henmi

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(54) **POWER SOURCE CIRCUIT SHUTOFF APPARATUS**

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H01H 35/00	(2006.01)
H01H 21/22	(2006.01)
H01H 27/00	(2006.01)
H01R 13/629	(2006.01)

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CPC ***H01H 35/003*** (2013.01); ***H01H 21/22*** (2013.01); ***H01H 27/00*** (2013.01); ***H01R 13/62938*** (2013.01)

(58) **Field of Classification Search**

CPC H01H 35/003; H01H 3/06
USPC 174/561; 200/335
See application file for complete search history.

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(57) **ABSTRACT**

In a power source circuit shutoff apparatus, with the lever rotated from a connector mating start position to a connector mating completion position, a pair of first signal terminals and a pair of second signal terminals are brought into on-state after a pair of first main terminals and a pair of second main terminals are brought into on-state. With the lever rotated from the connector mating completion position to the connector mating start position, a pair of first main terminals and a pair of second main terminal are brought into off-state after a pair of first signal terminals and a pair of second signal terminals are brought into off-state. The pair of first signal terminals and the pair of second signal terminals are each disposed along a straight line extending in a direction perpendicular to a rotational spindle direction of the lever.

5 Claims, 11 Drawing Sheets

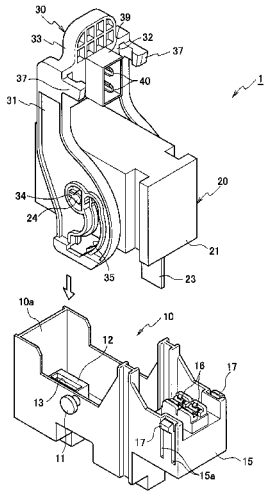

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FIG.1

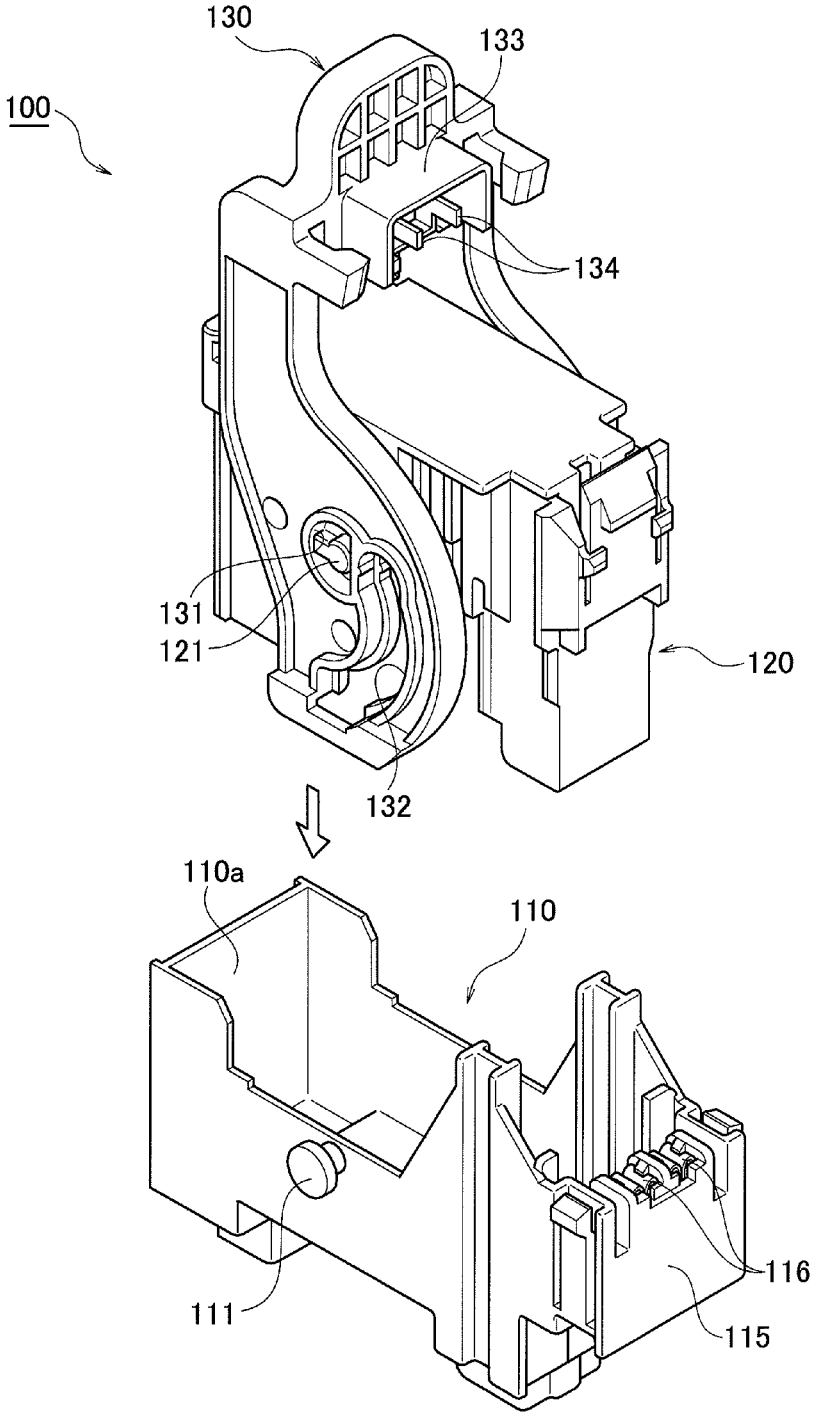


FIG.2

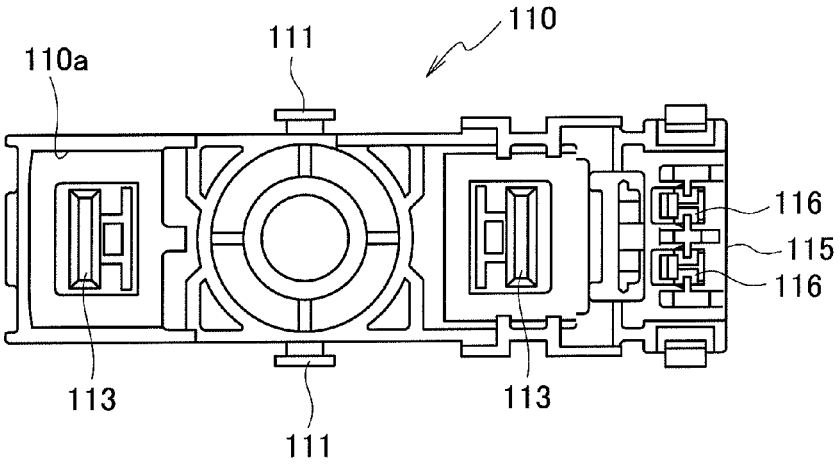

110
111
110a
116
115
116
113
113
111

FIG.3

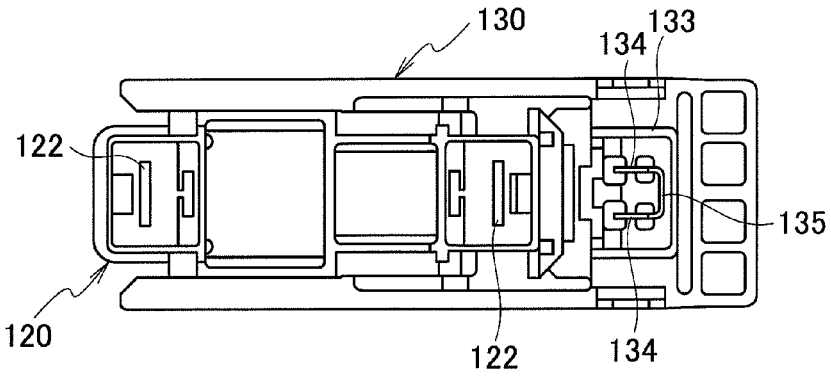

130
134
133
122
135
120
122
134

FIG.4

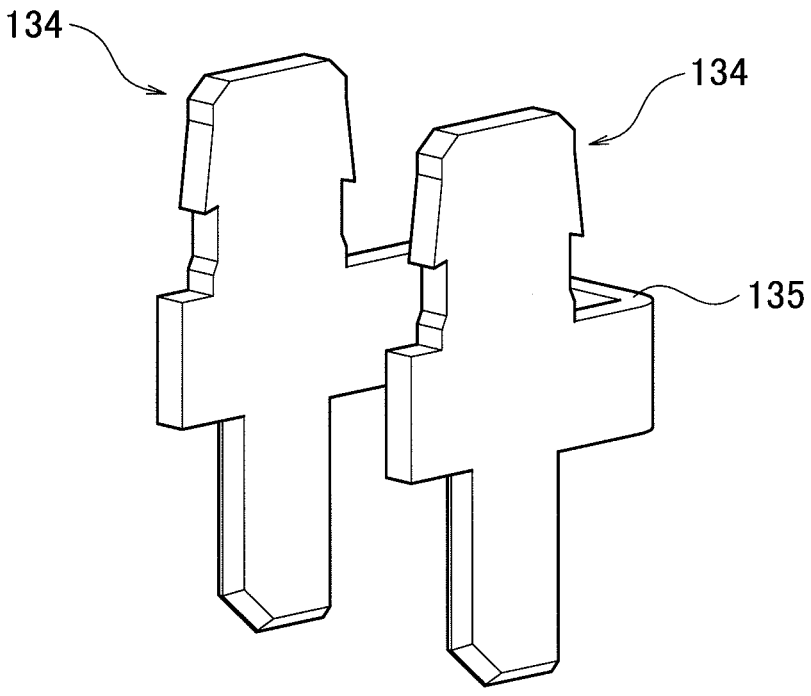


FIG.5

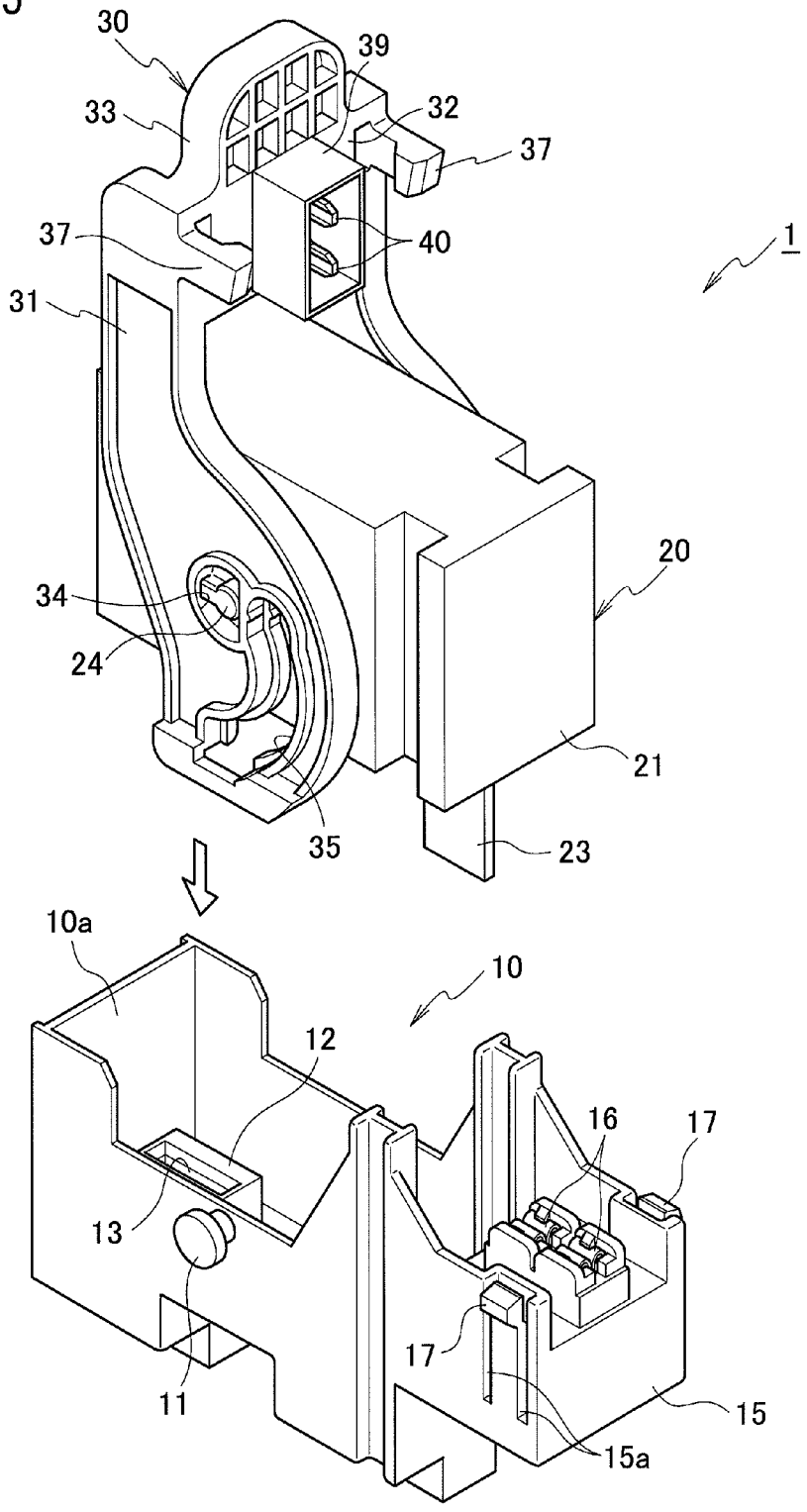

30
39
33
32
37
37
40
1
31
20
34
24
21
35
23
10a
10
12
16
17
13
17
11
15
15a

FIG.6

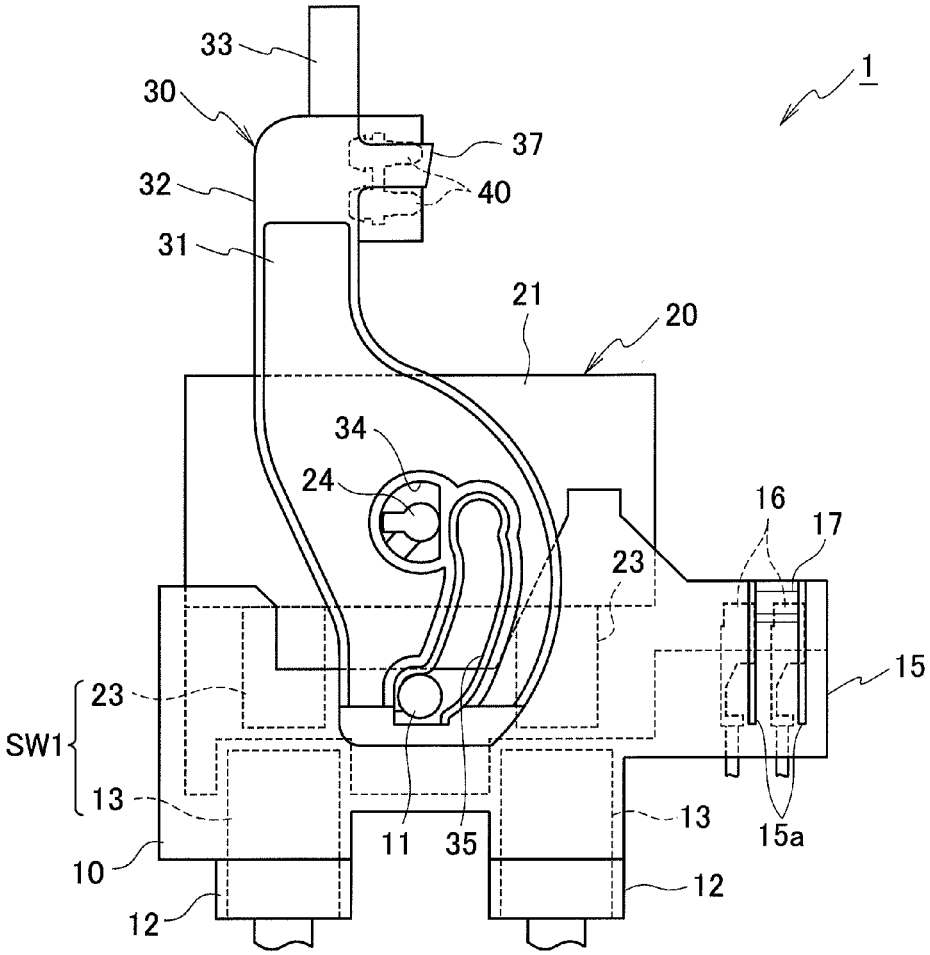

33
30
1
37
32
40
31
21
20
34
24
16
17
23
15
23
SW1
13
13
11
35
15a
10
12
12

FIG.7

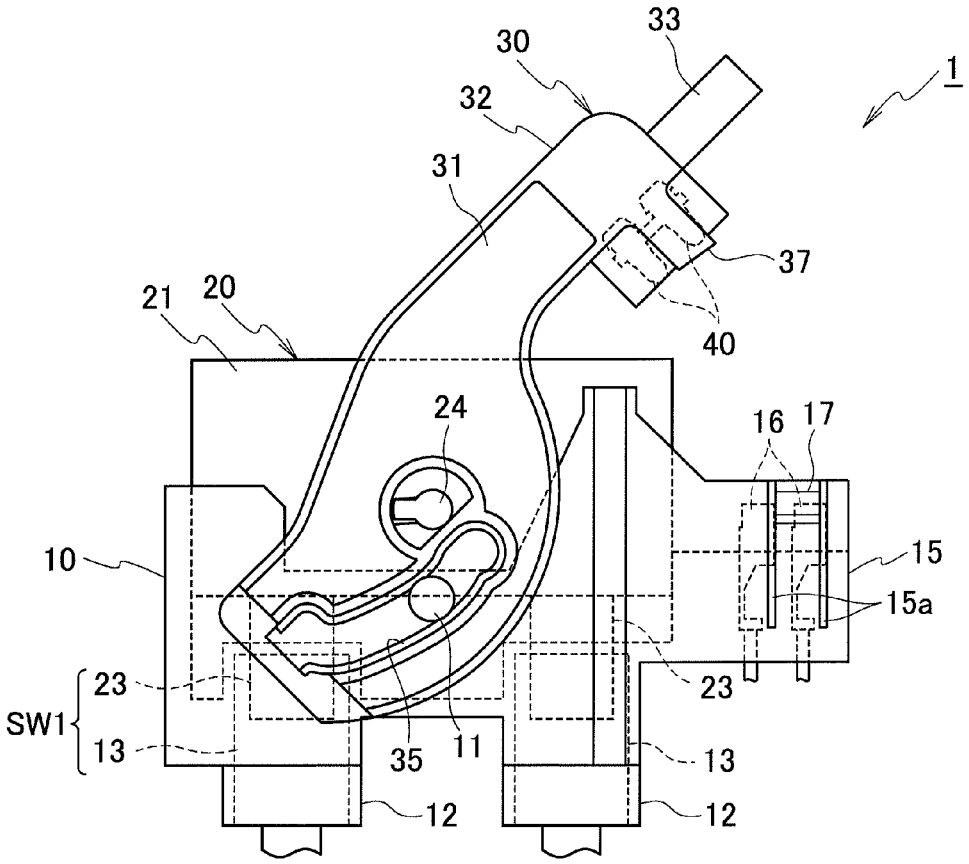


FIG.8

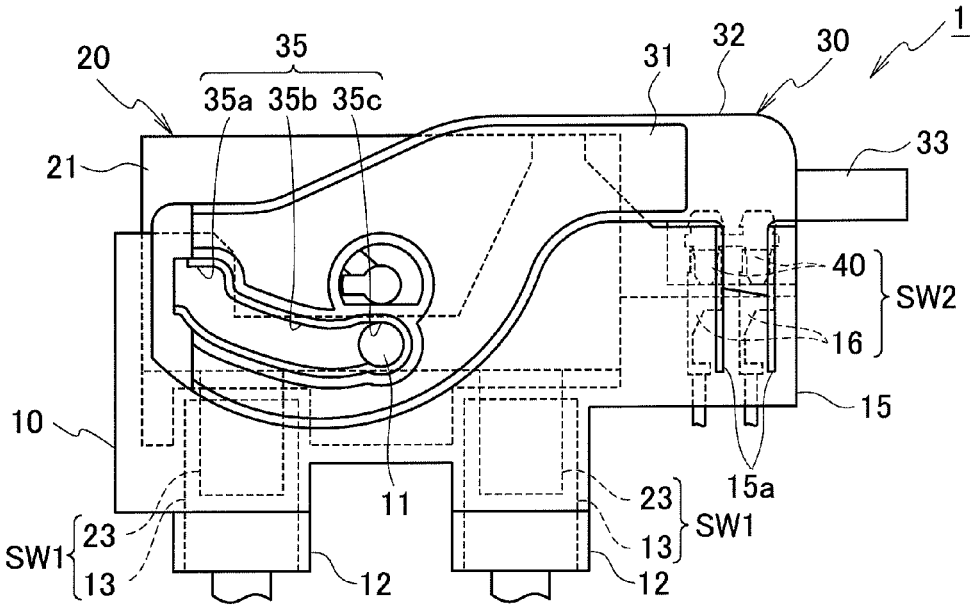

1
20
35
35a 35b 35c
31
32
30
21
33
40
SW2
16
15
10
11
15a
23
SW1
13
12
23
SW1
13
12

FIG.9

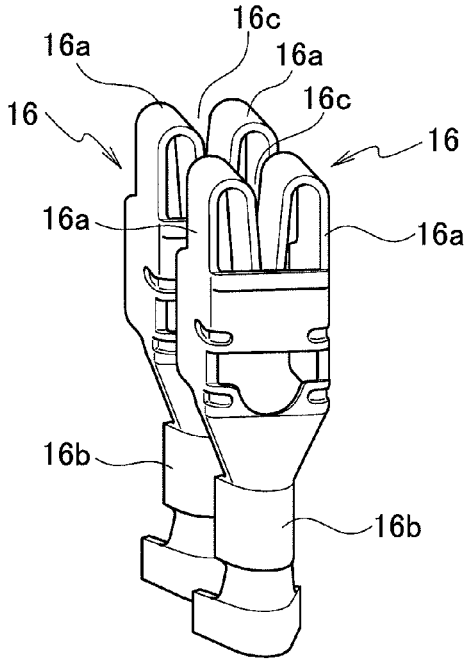


FIG.10

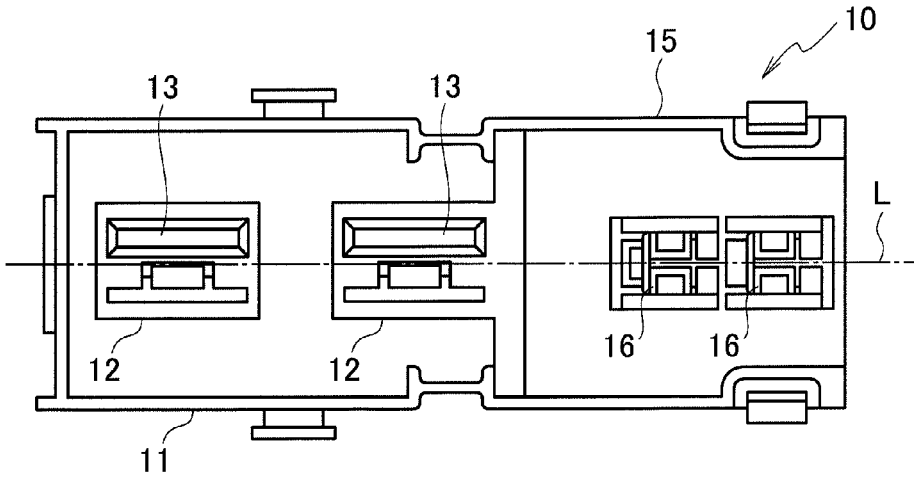


FIG.11A

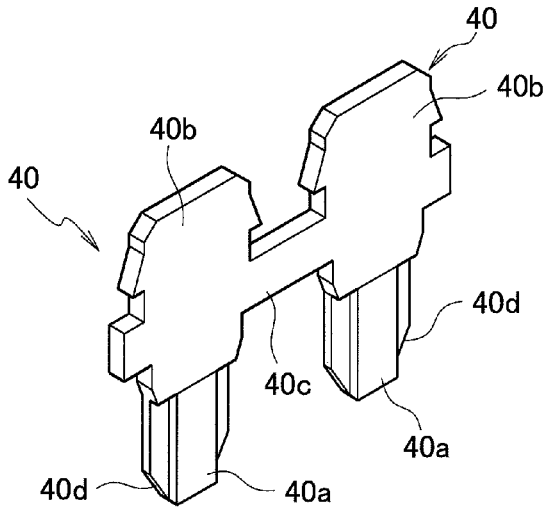


FIG.11B

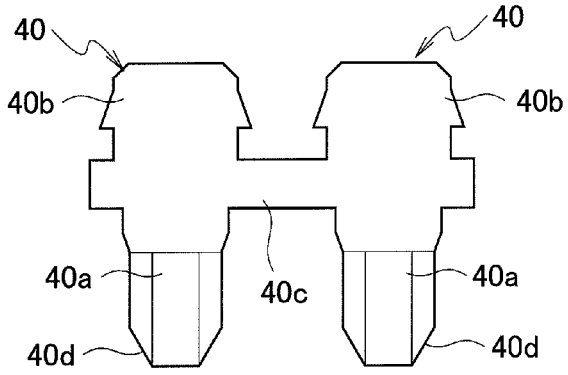


FIG.12

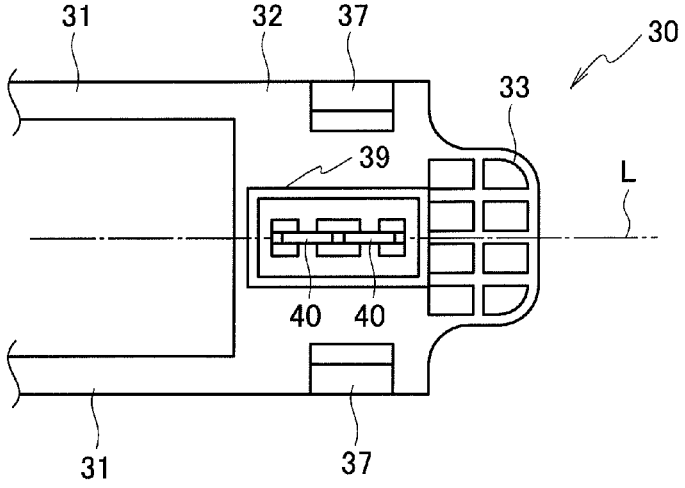


FIG.13

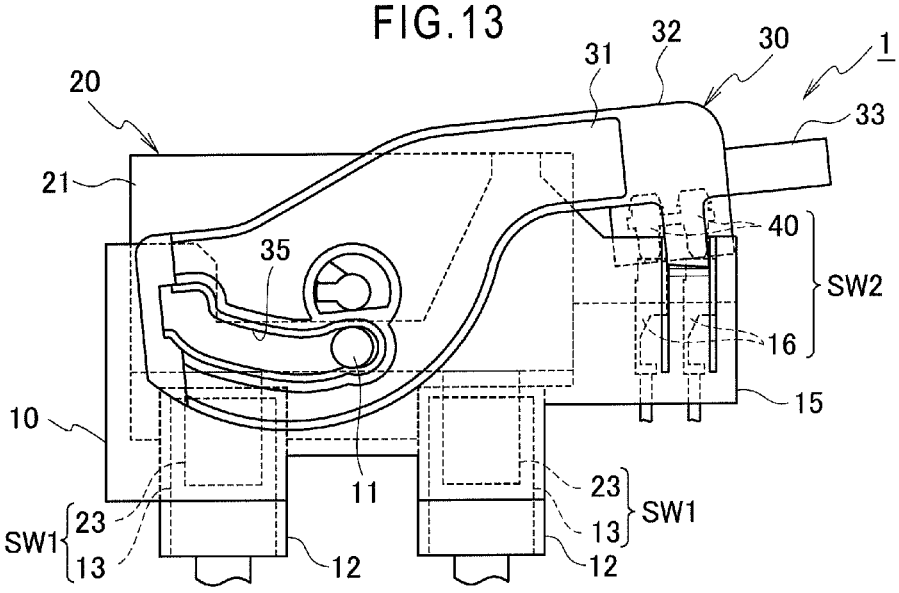

20
21
31
32
30
1
33
40
SW2
16
15
35
10
11
23
13
SW1
12

FIG.14

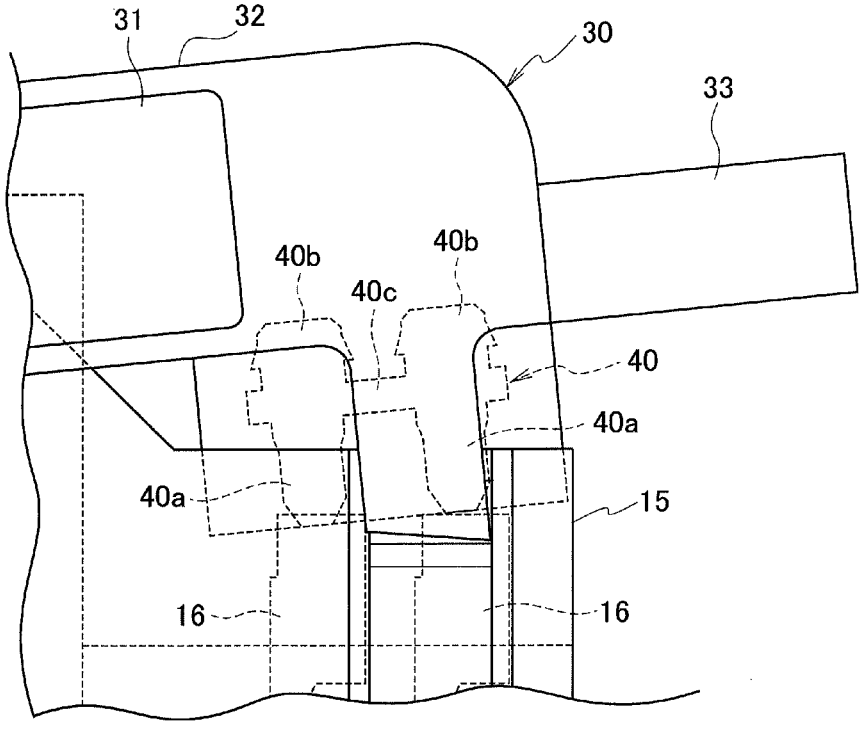
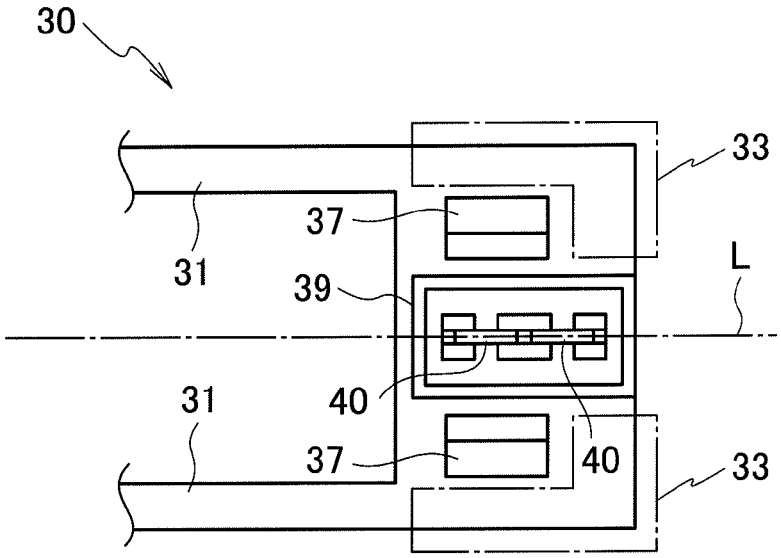

31
32
30
33
40b
40b
40c
40
40a
40a
15
16
16

FIG.15



POWER SOURCE CIRCUIT SHUTOFF APPARATUS

CROSS REFERENCE TO RELATED APPLICATION

This application claims benefit of priority under 35 U.S.C. §119 to Japanese Patent Application No. 2011-253839, filed on Nov. 21, 2011, the entire contents of which are incorporated by reference herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a power source circuit shutoff apparatus for connecting and shutting off a power source circuit by mating and separating connector housings equipped with a lever.

2. Description of the Related Art

Conventionally, in electric vehicles (EV) or hybrid electric vehicles (HEV), there is proposed a power source circuit shutoff apparatus (service plug) for shutting off an energizing between a power source portion and a load so as to secure operational safety in such occasions as maintenance of an electric system (for example, refer to Patent Literature 1 (Japanese Patent Unexamined Publication No. 2002-298704)).

As a power source circuit shutoff apparatus, the present inventor has proposed one shown in FIG. **1** to FIG. **4**. Specifically, as shown in FIG. **1** to FIG. **3**, a power source circuit shutoff apparatus **100** is provided with a first connector housing **110**, a second connector housing **120** configured to be mated with and separated from the first connector housing **110**, and a lever **130** rotatably provided at the second connector housing **120** and configured to cause a mating force or a separating force to the first connector housing **110** and the second connector housing **120** by rotation.

A pair of cam pins **111** are protrudingly provided on respective side faces of the first connector housing **110**. A pair of first main terminals **113** (refer to FIG. **2**) are disposed in a connector mating chamber **110***a* provided at the first connector housing **110**. A pair of first signal terminals **116** are disposed in an external hood portion **115** provided at the first connector housing **110**.

A pair of rotational shafts **121** (refer to FIG. **1**) are protrudingly provided on respective side faces of the second connector housing **120**. A pair of second main terminals **122** (refer to FIG. **3**) each of which is configured to be mated with and separated from one of the pair of first main terminals **113** are provided in the second connector housing **120**.

A pair of rotation receiving grooves **131** are formed on respective side faces of the lever **130**. Each of the pair of rotational shafts **121** of the second connector housing **120** is pivotally supported to one of the pair of rotation receiving grooves **131**. By this configuration, the lever **130** is rotatably supported on the second connector housing **120**. Further, a pair of cam grooves **132** are provided on respective side faces of the lever **130**. Each of a pair of cam pins **111** of the first connector housing **110** is inserted into one of the pair of cam grooves **132**. A pair of second signal terminals **134** are disposed in a hood portion **133** provided at a side face portion of the lever **130**.

A main circuit switch (not shown) includes the first main terminals **113** and the second main terminals **122**. On the other hand, a signal circuit switch (not shown) includes the first signal terminals **116** and the second signal terminals **134**.

Hereinafter, a conducting operation of a power source circuit of the power source circuit shutoff apparatus **100** will be explained. The second connector housing **120** is inserted into a connector mating chamber (not shown) of the first connector housing **110** and the cam pin **111** is inserted into an inlet of the cam groove **132** of the lever **130**. The first connector housing **110** and the second connector housing **120** are brought into a connector mating start state.

Rotating the lever **130** from a connector mating start position to a connector mating completion position side moves the cam pin **111** in the cam groove **132**, to thereby cause the mating force to the first connector housing **110** and the second connector housing **120** such that the second connector housing **120** is gradually inserted into the connector mating chamber of the first connector housing **110**. Then, the pair of first main terminals **113** and the pair of second main terminals **122** are brought into a contact state. This operation turns on the main circuit switch (not shown) in a connector mating operation position.

Further rotating of the lever **130** gradually brings the pair of first signal terminals **116** and the pair of second signal terminals **134** into contact with each other, thereby causing a complete contact state in the operation completion position of the lever **130**. This operation turns on a signal circuit switch (not shown) in the operation completion position of the lever **130**. In the power source circuit shutoff apparatus **100**, it is not until the pair of the signal terminals are brought into the on-state after the pair of the main terminals are brought into the on-state, that the power source circuit (not shown) is brought into the conduction state.

Further, the power shutoff operation of the power source circuit shutoff apparatus **100** can be implemented by operating the lever **130** in a reverse order of that stated above. This operation allows the power source circuit shutoff apparatus **100** to shutoff the power source circuit (not shown) at the time point when the first signal terminal **116** and the second signal terminal **134** are turned off, thus enabling to prevent occurrence of an arc discharge at the subsequent time point for switching the first main terminal **113** and second main terminals **122** to the off-state.

By the way, each of the pair of first signal terminals **116** and the pair of second signal terminals **134** are disposed along a rotational spindle direction of the lever **130** with an interval from each other, as shown in FIG. **2** and FIG. **3**. Specifically, each of the pair of first signal terminals **116** is in a form of a female terminal. On the other hand, each of the pair of second signal terminals **134** is in a form of a male terminal. The pair of second signal terminals **134** are, as shown in FIG. **4**, provided to be integrated with each other by a connecting plate portion **135** and are so bent by the connecting plate portion **135** as to be opposedly disposed.

With the power source circuit shutoff apparatus **100**, however, each of the pair of first signal terminals **116** and the pair of second signal terminals **134** are disposed in the rotational spindle direction of the lever **130** with an interval from each other. By this configuration, when the lever **130** is rotated from the connector mating start position to the connector mating completion position, the pair of second signal terminals **134** opposed to each other simultaneously contact the pair of first signal terminals **116**. Thus, the pair of second signal terminals **134** contacting the pair of first signal terminal **116** increase a power for rotating the lever **130**, thus causing such a fear as that the operability of the lever **130** may be lowered.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a power source circuit shutoff apparatus capable of improving the operability of a lever.

For solving the above problem, according to a first feature of the present invention, there is provided a power source circuit shutoff apparatus (power source circuit shutoff apparatus **1**) including: a first connector housing (first connector housing **10**) having a pair of first main terminals (first main terminals **13**) and a pair of first signal terminals (first signal terminals **16**); a second connector housing (second connector housing **20**) having a pair of second main terminals (second main terminals **23**) configured to be mated with and separated from the pair of the first main terminals, the second connector housing being configured to be mated with and separated from the first connector housing; a lever (lever **30**) having a pair of second signal terminals (second signal terminal **40**) configured to be mated with and separated from the pair of the first signal terminals, the lever being rotatably provided at the second connector housing and configured to cause a mating force and a separating force to the first connector housing and the second connector housing by a rotation; wherein with the lever rotated from a connector mating start position to a connector mating completion position, after the pair of the first main terminals and the pair of the second main terminals are brought into an on-state, the pair of the first signal terminals and the pair of the second signal terminal are brought into an on-state, with the lever rotated from the connector mating completion position to the connector mating start position, after the pair of the first signal terminals and the pair of the second signal terminals are brought into an off-state, the pair of the first main terminals and the pair of the second main terminal are brought into an off-state, the pair of the first signal terminals are disposed along a straight line (straight line L) extending in a direction perpendicular to a rotational spindle direction of the lever with an interval from each other, and the pair of the second signal terminals are disposed along the straight line (straight line L) with an interval from each other.

According to the first feature, each of the pair of first signal terminals and the pair of second signal terminals are disposed along the straight line extending in the direction perpendicular to the rotational spindle direction of the lever with the interval from each other. Thus, when the lever rotates from the connector mating start position to the connector mating completion position, the one of the first signal terminals and the one of the second signal terminals are brought into contact with each other and then the other of the first signal terminals and the other of the second signal terminals are brought into contact with each other. This can disperse the force for rotating the lever, thus enabling to improve the operability of the lever **30**.

Further, with the lever rotated from the connector mating completion position to the connector mating start position, the contact between the other of the first signal terminals and the other of the second signal terminals is canceled, and then the contact between the one of the first signal terminals and the one of the second signal terminal is canceled. This allows the signal circuit switch (SW**2**), which includes the pair of first signal terminals and the pair of second signal terminals, to be more rapidly brought into the off-state. Thus, an arc discharge caused between the pair of first main terminals and the pair of second main terminals can be suppressed.

According to a second feature of the present invention, the pair of the first signal terminals are disposed in a line-up manner along the straight line, and the pair of the second signal terminals are disposed in a line-up manner along the straight line.

According to the second feature, the pair of first signal terminals and the pair of second signal terminals each are disposed in a line-up manner along the straight line extending in the direction perpendicular to the rotational spindle direction of the lever. This eliminates the need of bending the pair of second signal terminals, unlike the conventional technology, and can shorten the length (connecting portion) between the pair of second signal terminals, thus enabling to reduce the production cost of the pair of second signal terminals.

According to a third feature of the present invention, the pair of the first main terminals are disposed along the straight line with an interval from each other, and the pair of the second main terminals are disposed along the straight line with an interval from each other.

According to the third feature, each of the pair of first main terminals and the pair of second main terminals are disposed along the straight line extending in the direction perpendicular to the direction of the rotational spindle direction of the lever with the interval from each other. This can narrow the width of each of the first connector housing and the second connector housing relative to the rotational spindle direction of the lever, thus enabling to increase a degree of freedom of the power source circuit shutoff apparatus.

According to a fourth feature of the present invention, the lever includes an operation portion (operation portion **33**) capable of operating the rotation of the lever, and the operation portion is provided closer to a rotational distal end side than to a position of the pair of the second signal terminals.

According to the fourth feature, the operating portion is provided closer to the rotational distal end side than to the position of the pair of second signal terminals. This can narrow the width of the lever relative to the rotational spindle direction of the lever, thus increasing the degree of freedom of the power source circuit shutoff apparatus.

According to a fifth feature of the present invention, the lever includes an operation portion capable of operating the rotation of the lever, and the operation portion is provided on a lateral side in a position of the pair of the second signal terminals.

According to the fifth feature, the operating portion is provided on the lateral side of the pair of second signal terminals. This can shorten the length of the lever relative to the direction perpendicular to the rotational spindle direction of the lever, thus enabling to increase the degree of freedom of the power source circuit shutoff apparatus.

The features of the present invention can provide a power source circuit shutoff apparatus capable of improving the operability of a lever and reducing the production cost of a pair of second signal terminals.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exploded perspective view of a power source circuit shutoff apparatus **100** according to a related art.

FIG. **2** is a plan view of a first connector housing **110** according to the related art.

FIG. **3** is a plan view of a part (near a second signal terminal **134**) of a lever **130** according to the related art.

FIG. **4** is a perspective view of a second signal terminal **134** according to the related art.

FIG. **5** is an exposed perspective view of a power source circuit shutoff apparatus **1** according to an embodiment of the present invention.

FIG. **6** is a side view showing a state before mating a first connector housing **10** with a second connector housing **20** according to the embodiment of the present invention.

FIG. **7** is a side view showing a midway state of mating the first connector housing **10** with the second connector housing **20** according to the embodiment of the present invention.

FIG. **8** is a side view showing a state that the first connector housing **10** are mated with the second connector housing **20** according to the embodiment of the present invention.

FIG. **9** is a perspective view of a first signal terminal **16** according to the embodiment of the present invention.

FIG. **10** is a plan view of the first connector housing (near the first signal terminal **16**) according to the embodiment of the present invention.

FIG. **11**A is a perspective view of a second signal terminal **40** according to the embodiment of the present invention.

FIG. **11**B is a front view of the second signal terminal **40** according to the embodiment of the present invention.

FIG. **12** is a plan view of a part (near the second signal terminal **40**) of a lever **30** according to the embodiment of the present invention.

FIG. **13** is a side view showing a state immediately before the first signal terminal **16** is mated with the second signal terminal **40** according to the embodiment of the present invention.

FIG. **14** is an enlarged side view of FIG. **13**.

FIG. **15** is a plan view showing a part (near the second signal terminal **40**) of the lever **30** according to a modified example of the embodiment of the present invention.

DESCRIPTION OF THE EMBODIMENTS

Hereinafter, a power source circuit shutoff apparatus according to an embodiment of the present invention will be explained with reference to drawings. Specifically, an explanation will be made about (1) structure of the power source circuit shutoff apparatus, (2) structure of signal terminals, (3) structure of main terminals, (4) structure of a power source circuit, (5) operations and effects, (6) modified example, and (7) other embodiments.

Further, in the description of the following drawings, same or similar reference numerals or signs will be assigned to same or similar portions. However, since the drawings are schematic, ratios and the like of respective dimensions are different from those of actual ones.

Thus, specific dimensions and the like should be determined in view of the following explanations. Further, in the drawings, portions having different dimensional relations or different dimensional ratios are included.

(1) Structure of Power Source Circuit Shutoff Apparatus

First, the structure of the power source circuit shutoff apparatus **1** according to the embodiment will be explained with reference to the drawings. FIG. **5** is an exploded perspective view of the power source circuit shutoff apparatus **1** according to the embodiment. FIG. **6** is a side view showing a state before mating a first connector housing **10** with a second connector housing **20** according to the embodiment. FIG. **7** is a side view showing a midway state of mating the first connector housing **10** with the second connector housing **20** according to the embodiment. FIG. **8** is a side view showing a state that the first connector housing **10** are mated with the second connector housing **20** according to the embodiment.

As shown in FIG. **5** to FIG. **8**, the power source circuit shutoff apparatus **1** is provided with a first connector housing **10**, a second connector housing **20** configured to be mated with and separated from the first connector housing **10**, and a lever **30** rotatably provided at the second connector housing **20** and configured to cause a mating force or a separating force to the first connector housing **10** and the second connector housing **20** by rotation.

A pair of cam pins **11** are protrudingly provided on respective side faces of the first connector housing **10**. The first connector housing **10** has a connector mating chamber **10***a* having an upper face opened. Two internal terminal hood portions **12** are provided in the connector mating chamber **10***a*. A pair of first main terminals **13** each as a female terminal are provided in the respective internal terminal hood portions **12**.

The first connector housing **10** has an external terminal hood portion **15** provided outside the connector mating chamber **10***a*. The external terminal hood portion **15** has an upper portion opened. A pair of first signal terminals **16** each as a female terminal are provided in the external terminal hood portion **15**.

A pair of first locked portions **17** are protrudingly provided on respective side walls of the external terminal hood portion **15**. The first locked portion **17** is so configured as to be saggingly deformed with ease by a pair of slits **15***a* on a side wall of the external terminal hood portion **15**.

The second connector housing **20** is provided with a housing body **21** receiving therein a fuse (not shown). This housing body **21** has such a dimension and a configuration as to be capable of being mated with and separated from the connector mating chamber **10***a* and the external terminal hood portion **15** of the first connector housing **10**. The housing body **21** is provided with a pair of second main terminals **23** each configured to be mated with and separated from one of the pair of first main terminals **13** and each formed into a plate body as a male terminal. A pair of rotational spindles **24** are protrudingly provided on respective side faces of the housing body **21**.

Each of the second main terminals **23** protrudes downward from the housing body **21**. The second main terminals **23** are connected with each other via a fuse (not shown). Further, the pair of first main terminals **13** of the first connector housing **10** and the pair of second main terminals **23** on the second connector housing **20** constitute a main circuit switch SW**1**.

The lever **30** is provided with a pair of arm plate portions **31**, a connecting portion **32** for connecting the pair of arm plate portions **31** with each other at respective rotational distal end sides, and an operating portion **33** capable of operating rotation of the lever **30**.

Each of a pair of arm plate portions **31** is provided with one of a pair of rotation receiving portions **34**. Each of a pair of rotational spindles **24** is pivotally supported by one of the pair of rotation receiving portions **34**. This configuration allows the lever **30** to be rotatably supported on the second connector housing **20**. Each of a pair of cam grooves **35** is formed at one of the arm plate portions **31**. Each of a pair of first locking portions **37** is disposed at a rotational distal end side of and in a lower position of one of the pair of arm plate portions **31**.

A cam pin **11** of the first connector housing **10** is inserted into each of the pair of cam grooves **35**. As shown in FIG. **8**, the cam groove **35** has an entry straight portion **35***a* into which the cam pin **11** can enter, a curved portion **35***b* communicating with the entry straight portion **35***a* and having a distance gradually variable from a center of the rotation receiving portion **34**, and a circular arc portion **35***c* communicating with the curved portion **35***b* and having a constant distance from the center of the rotation receiving portion **34**.

With the cam pin **11** moving in the cam groove **35**, the lever **30** rotates from the connector mating start position of the lever **30** to the connector mating completion position via the connector mating operation position. Further, in the connector mating start position, the cam pin **11** is positioned in the entry straight portion **35***a* (refer to FIG. **6**). In the connector mating operation position, the cam pin **11** is positioned in a

boundary position between the curved portion **35***b* and the circular arc portion **35***c* (refer to FIG. **7**). In the connector mating completion position, the cam pin **11** is positioned in the innermost position of the circular arc portion **35***c* (refer to FIG. **8**).

That is, in the rotating process of the lever **30** between the connector mating start position and the connector mating operation position, the cam pin **11** is moveable in the curved portion **35***b*, thus causing the mating force or the separating force to the first connector housing **10** and the second connector housing **20**. This operation moves the first connector housing **10** and the second connector housing **20** in the mating direction or the separating direction.

Further, with the lever **30** in the connector mating completion position, the cam pin **11** is positioned in the circular arc portion **35***c*, thus failing to cause the mating force or the separating force to the first connector housing **10** and the second connector housing **20**, thereby preventing the movement of the first connector housing **10** and second connector housing **20** in the mating direction or the separating direction.

A hood portion **39** is provided in the lower portion of the operating portion **33**. The hood portion **39** is opened downward. A pair of second signal terminals **40** configured to be mated with and separated from the pair of first signal terminals **16** and each formed into a plate as a male terminal are provided in the hood portion **39**. The operating portion **33** is provided closer to a rotational distal end side than to the position of the pair of the second signal terminal **40**. Further, the pair of first signal terminals **16** of the first connector housing **10** side and the pair of second signal terminals **40** of the lever **30** side constitute a signal circuit switch SW**2** (refer to FIG. **8**).

(2) Structure of Signal Terminals

Next, the structure of the first signal terminal **16** and the second signal terminal **40** will be explained with reference to the drawings. FIG. **9** is a perspective view of the first signal terminal **16** according to the embodiment. FIG. **10** is a plan view of the first connector housing **10** (near the first signal terminal **16**) according to the embodiment. FIGS. **11**A and **11**B are respectively a perspective view and a front view of the second signal terminal **40** according to the embodiment. FIG. **12** is a plan view of a part (near the second signal terminal **40**) of the lever **30** according to the embodiment.

As shown in FIG. **9**, each first signal terminal **16** is provided with a pair of plate spring contacts **16***a* and an electric wire crimping portion **16***b* integrally connected with the pair of plate spring contacts **16***a*. The pair of plate spring contacts **16***a* each have a distal end side bent inward in a form of a substantial R-letter shape, and an opening **16***c* is formed between the bent portions of the plate spring contacts **16***a* and has a wide inlet side and a narrow back side.

The pair of first signal terminals **16** (the openings **16***c*) are, as shown in FIG. **10**, disposed in a line-up manner along a straight line L extending in a direction perpendicular to the rotational spindle direction of the lever **30** with an interval from each other.

On the other hand, as shown in FIGS. **11**A and **11**B, each second signal terminal **40** is provided with a tab-shaped contact **40***a* and a support portion **40***b* connected to be integrated with the tab-shaped contact **40***a*. The support portions **40***b* are connected with each other by a connecting portion **40***c*. An edge portion disposed at a distal end of the tab-shaped contact **40***a* and configured to have a first contact with the first signal terminal **16** is formed as a taper face **40***d*.

So as to be mated with and separated from the pair of first signal terminals **16**, as shown in FIG. **12**, the pair of second signal terminals **40** are disposed in a line-up manner along the straight line L extending in the direction perpendicular to the rotational spindle direction of the lever **30** with the interval from each other. Specifically, the pair of second signal terminals **40** are disposed in a line-up manner on the straight line L with the interval from each other such that a width direction of the pair of second signal terminals **40** is along the straight line L. The pair of first signal terminals **16** are disposed in a line-up manner on the straight line L with the interval from each other such that the pair of first signal terminals **16** can receive the pair of second signal terminals **40** disposed in the above manner.

(3) Structure of Main Terminals

Next, the structure of the first main terminal **13** and the second main terminal **23** will be explained with reference to the drawings.

As shown in FIG. **10**, the pair of first main terminals **13** (an opening into which the second main terminal **23** is inserted) are disposed along the straight line L extending in the direction perpendicular to the rotational spindle direction of the lever **30** with the interval from each other.

On the other hand, as shown in FIGS. **5** to **8** and the like, the pair of second main terminals **23** are disposed, so as to be mated with and separated from the pair of first main terminals **13**, along the straight line L (refer to FIG. **12**) extending in the direction perpendicular to the rotational spindle direction of the lever **30** with the interval from each other. Specifically, the pair of second main terminals **23** are disposed in a line-up manner on the straight line L with the interval from each other such that a width direction of the pair of second main terminals **23** is along the straight line L. The pair of first main terminals **13** are disposed in a line-up manner on the straight line L with the interval from each other such that the pair of first main terminals **13** can receive the pair of second main terminals **23** disposed in the above manner.

(4) Structure of Power Source Circuit

Next, the structure of the power source circuit associated with the power source circuit shutoff apparatus **1** will be briefly explained. A relay (not shown) to be turned on and off by the signal circuit switch SW**2**, and the main circuit switch SW**1** are connected in series between the power source portion (not shown) and the load portion (not shown). Thus, the main circuit switch SW**1** and the signal circuit switch SW**2** turned on together bring the power source circuit into an on-state. In other switch conditions, the power source circuit is in an off-state.

(4.1) Operation of Power Source Circuit

Next, conduction operations of the power source circuit by the power source circuit shutoff apparatus **1** will be explained, referring to FIG. **5** to FIG. **8**, FIG. **13** and FIG. **14**. FIG. **13** is a side view showing a state immediately before the first signal terminal **16** is mated with the second signal terminal **40** according to the embodiment. FIG. **14** is an enlarged side view of FIG. **13**.

First, as shown in FIG. **5**, as the connector mating start position of the lever **30**, the second connector housing **20** is aligned with the connector mating chamber **10***a* of the first connector housing **10**. Then, as shown in FIG. **6**, the second connector housing **20** is inserted into the connector mating chamber **10***a* of the first connector housing **10**, and the cam pin **11** is inserted into the entry straight portion **35***a* of the cam

groove **35** of the lever **30**. The first connector housing **10** and the second connector housing **20** are brought into a connector temporary mating state. In this case, the pair of the first main terminals **13** and the pair of the second main terminals **23** are brought into an off-state together, and the pair of first signal terminals **16** and the pair of the second signal terminals **40** are also brought into an off-state.

Next, as shown in FIG. **7**, the lever **30** is caused to rotate from the connector mating start position to the connector mating completion position side. Then, the cam pin **11** moves in the cam groove **35** to thereby cause the mating force to the first connector housing **10** and the second connector housing **20**, so that the second connector housing **20** is gradually inserted into the connector mating chamber **10***a* of the first connector housing **10**.

Then, the lever **30** is rotated to the connector mating operation position, to thereby bring the first connector housing **10** and the second connector housing **20** into a complete mating state. In the process from the connector mating operation position to the connector mating completion position, the pair of first main terminals **13** and the pair of second main terminals **23** are brought into the on-state, thus bringing the main circuit switch SW**1** into the on-state. In this case, the pair of first signal terminals **16** and the pair of second signal terminals **40** are in the off-state.

As shown in FIG. **13** and FIG. **14**, further rotating the lever **30** to the connector mating completion position side causes one (left in FIG. **13** and FIG. **14**) of the first signal terminals **16** and one (left in FIG. **13** and FIG. **14**) of the second signal terminals **40** to have a contact with each other and then causes the other (right in FIG. **13** and FIG. **14**) of the first signal terminals **16** and the other (right in FIG. **13** and FIG. **14**) of the second signal terminals **40** to have a contact with each other.

Then, as shown in FIG. **8**, rotating the lever **30** up to the connector mating completion position locks the first locking portion **37** to the first locked portion **17**. In the rotation of the lever **30** from the connector mating start position to the connector mating completion position, after the pair of first main terminals **13** and the pair of second main terminals **23** are brought into the on-state, the contact between the pair of first signal terminals **16** and the pair of second signal terminals **40** is brought into the on-state, to thereby bring the signal circuit switch SW**2** into the on-state. Further, the power source circuit is non-conductive with the lever **30** in the connector mating operation position and then is at last brought into a conductive state with the lever **30** in the connector mating completion position.

(4.2) Power Source Shutoff Operation of Power Source Circuit

Next, power source shutoff operations of the power source circuit by the power source circuit shutoff apparatus **1** will be explained with reference to FIG. **5** to FIG. **8**, FIG. **13** and FIG. **14**.

First, as shown in FIG. **8**, with the lever **30** in the connector mating completion position, the lever **30** is rotated to the connector mating start position side by a rotational force greater than a lock force between the first locked portion **17** and the first locking portion **37**. Then, the locking between the first locked portion **17** and the first locking portion **37** is unlocked, to thereby allow the lever **30** to rotate. As shown in FIG. **7**, this makes the lever **30** rotatable in the connector completion mating operation position.

In the process of rotating the lever **30** from the connector mating completion position to the connector mating operation position, as shown in FIG. **13** and FIG. **14**, the contact between the other (right in FIG. **13** and FIG. **14**) of the first signal terminals **16** and the other (right in FIG. **13** and FIG. **14**) of the second signal terminals **40** is canceled, and then the contact between the one (left in FIG. **13** and FIG. **14**) of the first signal terminals **16** and the one (left in FIG. **13** and FIG. **14**) of the second signal terminals **40** is canceled. Thus, with the lever **30** in the connector mating operation position, the signal circuit switch SW**2** is brought into the off-state. This makes the power source circuit non-conductive when the lever **30** is in the connector mating operation position.

Next, when the lever **30** rotates up to the connector mating start position, the cam pin **11** and the cam groove **35** together cause a separating force to the first connector housing **10** and the second connector housing **20**, to thereby gradually pull out the second connector housing **20** from the connector mating chamber **10***a* of the first connector housing **10**.

As shown in FIG. **6**, with the lever **30** in the connector mating start position, the first connector housing **10** and the second connector housing **20** are brought into the temporary mating state. The contact between the first main terminals **13** and the second main terminals **23** is gradually canceled in the process from the connector mating operation position to the connector mating start position, and then the first main terminals **13** and the second main terminals **23** are completely brought into a non-conductive state in the connector mating start position. That is, with the lever **30** rotated from the connector mating completion position to the connector mating start position, after the contact between the pair of first signal terminals **16** and the pair of second signal terminals **40** is brought into the off-state, the pair of first main terminals **13** and the pair of second main terminals **23** are brought into the off-state, to thereby bring the main circuit switch SW**1** into the off-state.

(5) Operations and Effects

According to the embodiment, each of the pair of first signal terminals **16** and the pair of second signal terminals **40** are disposed along the straight line L extending in the direction perpendicular to the rotational spindle direction of the lever **30** with the interval from each other. Thus, rotation of the lever **30** from the connector mating start position to the connector mating completion position causes the one of the first signal terminals **16** and the one of the second signal terminals **40** to have a contact with each other and, then, causes the other of the first signal terminals **16** and the other of the second signal terminals **40** to have a contact with each other. This can disperse the force for rotating the lever **30**, thus enabling to improve the operability of the lever **30**.

Further, with the lever **30** rotated from the connector mating completion position to the connector mating start position, the contact between the other of the first signal terminals **16** and the other of the second signal terminals **40** is canceled, and then the contact between the one of the first signal terminals **16** and the one of the second signal terminal **40** is canceled. This allows the signal circuit switch SW**2**, which includes the pair of first signal terminals **16** and the pair of second signal terminals **40**, to be more rapidly brought into the off-state. Thus, an arc discharge caused between the pair of first main terminals **13** and the pair of second main terminals **23** can be suppressed.

According to the embodiment, the pair of first signal terminals **16** and the pair of second signal terminals **40** are disposed along the straight line L extending in the direction perpendicular to the rotational spindle direction of the lever **30**. This eliminates the need of bending the pair of second signal terminals **40**, unlike the conventional technology, and can shorten the length (connecting portion **40***c*) between the

pair of second signal terminals **40**, thus enabling to reduce the production cost of the pair of second signal terminals **40**.

According to the embodiment, each of the pair of first main terminals **13** and the pair of second main terminals **23** are disposed along the straight line L extending in the direction perpendicular to the direction of the rotational spindle direction of the lever **30** with the interval from each other. This can narrow the width of each of the first connector housing **10** and the second connector housing **20** relative to the rotational spindle direction of the lever **30**, thus enabling to increase a degree of freedom of the power source circuit shutoff apparatus **1**.

According to the embodiment, the operating portion **33** is provided closer to the rotational distal end side than to the position of the pair of second signal terminals **40**. This can narrow the width of the lever **30** relative to the rotational spindle direction of the lever **30**, thus increasing the degree of freedom of the power source circuit shutoff apparatus **1**.

(6) Modified Example

Next, the power source circuit shutoff apparatus **1** according to a modified example of the embodiment will be explained with reference to the drawings. FIG. **15** is a plan view showing a part (near the second signal terminal **40**) of the lever **30** according to the modified example. Further, same reference numerals or signs will be assigned to same portions as those of the power source circuit shutoff apparatus **1** according to the embodiment set forth above, and different portions will be mainly explained.

According to the embodiment, the operating portion **33** is provided closer to the rotational distal end side than to the position of the pair of second signal terminals **40**. Contrary to this, according to the modified example, as shown in FIG. **15**, the operating portion **33** is provided on a lateral side of the pair of second signal terminals **40** (that is, the rotational spindle direction side of the lever **30**).

According to the modified example, the operating portion **33** is provided on the lateral side of the pair of second signal terminals **40**. This can shorten the length of the lever **30** relative to the direction perpendicular to the rotational spindle direction of the lever **30**, thus enabling to increase the degree of freedom of the power source circuit shutoff apparatus **1**.

(7) Other Embodiment

As described above, the contents of the present invention have been disclosed according to the embodiments. However, the explanations and drawings constituting a part of this disclosure shall not limit the present invention. From this disclosure, various alternative embodiments, examples and operational technologies will be obvious to a person skilled in the art.

For example, the embodiment can be changed in the following manner. Specifically, it is not necessary for the pair of first main terminals **13** to be disposed in a line-up manner along the straight line L, but they may be so disposed as to oppose each other. Likewise, it is not necessary for the pair of second main terminals **23** to be disposed in a line-up manner along the straight line L, but they may be so disposed as to oppose each other.

Further, it is not necessary for the pair of first signal terminals **16** (openings **16***c*) to be disposed in a line-up manner along the straight line L, provided that the first signal terminals **16** are disposed along the straight line L with the interval from each other. For example, the pair of first signal terminals **16** may be so disposed as to oppose each other. Likewise, it is not necessary for the pair of second signal terminals **40** to be disposed in a line-up manner along the straight line L, provided that the second signal terminals **40** are disposed along the straight line L with the interval from each other. For example, the pair of second signal terminals **40** may be so disposed as to oppose each other.

As set forth above, it is a matter of course that the present invention includes various other embodiments not described herein. Thus, the technical scope of the present invention is defined only by the inventive specific matters according to the scope of claims which is proper from the above explanations.

What is claimed is:

1. A power source circuit shutoff apparatus comprising:

a first connector housing having a pair of first main terminals and a pair of first signal terminals;

a second connector housing having a pair of second main terminals configured to be mated with and separated from the pair of the first main terminals, the second connector housing being configured to be mated with and separated from the first connector housing; and

a lever having a pair of second signal terminals configured to be mated with and separated from the pair of the first signal terminals, the lever being rotatably provided at the second connector housing and configured to cause a mating force or a separating force to the first connector housing and the second connector housing by a rotation,

wherein

with the lever rotated from a connector mating start position to a connector mating completion position, after the pair of the first main terminals and the pair of the second main terminals are brought into an on-state, the pair of the first signal terminals and the pair of the second signal terminals are brought into an on-state,

with the lever rotated from the connector mating completion position to the connector mating start position, after the pair of the first signal terminals and the pair of the second signal terminals are brought into an off-state, the pair of the first main terminals and the pair of the second main terminals are brought into an off-state,

the pair of the first signal terminals are disposed directly on a straight line extending in a direction perpendicular to a rotational spindle direction of the lever with an interval from each other, and

the pair of the second signal terminals are disposed directly on the straight line with an interval from each other.

2. The power source circuit shutoff apparatus according to claim **1** wherein

the pair of the first main terminals are disposed along the straight line with an interval from each other, and

the pair of the second main terminals are disposed along the straight line with an interval from each other.

3. The power source circuit shutoff apparatus according to claim **1** wherein

the lever includes an operation portion capable of operating the rotation of the lever, and

the operation portion is provided closer to a rotational distal end side than to a position of the pair of the second signal terminals.

4. The power source circuit shutoff apparatus according to claim **1** wherein

the lever includes an operation portion capable of operating the rotation of the lever, and

the operation portion is provided on a lateral side in a position of the pair of the second signal terminals.

5. The power source circuit shutoff apparatus according to claim **1**, wherein a width direction of the pair of the first main terminals is along the straight line, and

a width direction of the pair of the second main terminals is along the straight line.

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